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ORIGIN OF THE LOESS.

BY JNO. T. CAMPBELL.

THE loess, as understood in Indiana, is a thin sheet of very fine clay, or a sand so fine that it appears like clay, which covers the glacial drift. That the boulder clay, or till, here, is the work of an extinct glacier, is more evident the more it is studied. I have no more doubt of the past existence of a glacier here, than if I had been present when it existed, and seen it myself. But how came the fine yellow or buff-colored, and in many places ash-colored, clay on top of the glacial clay. To every observer the first thought that will occur is that it is the sediment from a body of still water. Next query—How did the water originate?—for it must be fresh water. Well, the melting glacier furnished it. Very well. A little more observation, and we find the clay at elevations rather high for a glacial pond to cover. Then we construct imaginary ice dams to hold the water in sufficient depth and time to make the deposits we find. Following our investigations southward we find the loess almost to the Mexican Gulf, where not only ice melts, but alligator eggs hatch in the sand; yet we construct an imaginary ice dam below the most southern loess to account for it. Then the ice dam theory becomes absurd, and we cast about for another cause. The wind-sifted sand from the western desert next suggests the cause. But it too has difficulties to be reconciled and harmonized that seem insurmountable.

If the clay were due to glacial lake deposits, we should expect the lowest valleys to contain the thickest beds of clay. But in my locality (Rockville, Ind.) the reverse is true. The highest land, and ridges in particular, have the thickest yellow clay, free from coarse sand and gravel.

What cause or causes could produce this clay that will not be contradicted by well-known existing facts?

I suggest some causes now at work that I think could and *did* produce the clay in question.

Some writer whom I have read often, Prof. G. K. Gilbert I think, said (in substance) he always liked to have all the steps, processes and observations by and from which an investigator has arrived at his conclusions. I like this myself, and shall, at the risk of being tedious to the reader, give my observations, impressions, conclusions, changes of opinion, disappointments, etc. Up to and for several years after 1872 I accepted the teachings of the books on Dynamic Geology with childish confidence. I supposed the surface, gravel-less clay was the sedimentation of a still lake. That year (1872) I had occasion to cut down a sugar maple tree in what is now the fair ground at Rockville, Indiana. The tree was about twenty inches in diameter at the stump. When it fell, the stump was so nearly sound that I did not notice a very small decay in the heart. I cut off eight feet of butt, and split it into quarters. It split as easy and straight as pine. When I halved it, I found a long, cigar-shaped, rotten heart, six feet long, by about six inches diameter. The centre of this rotten place was as perfect yellow clay as I ever saw. The fine grit could be easily detected by the teeth. Following it from the centre to the sides and toward the ends, the clay gradually changed to wet, soft, rotten wood. There was no distinct line where the clay ended and the rotten wood began. This was a curiosity to me, and I kept the sample several years. There was no hole in the body of the tree where any insect could then carry the clay in, and I doubt if there ever had been a hole grown over and closed over by concentric growths of the tree. I showed this to many people and told it to many more, and among the number to my teacher, Prof. B. C. Hobbs (Ex-Supt. Pub. Inst. Ind.). Being a Quaker he replied thus: "Thou hast not carefully observed it. A crawfish working up from below happened to strike the hollow of the tree, and kept hunting upwards for the surface of the mound, and thus filled the cavity of the tree with clay." A few days later I took my axe and visited the stump. The decay at the heart on the top was so small I could not put my fingers in it; but I cut the stump off a foot lower, and there it was entirely solid and sound. How came that clay to be sealed up in that tree? was the query. I then kept a watch out for all rotten logs and stumps that came in my way, and found that in very many of them there was a strong resemblance to the yellow clay, but I never again found as perfect a sample as the sugar tree mentioned. I often found grains of sand in the heart of rotten stumps and logs, where I could not see any possibility of its being carried in by insects. I have found gallons of rotten wood and sand mixed in the hollows of trees fifty feet or more above ground, where the rains in following down the bodies and limbs would trickle inside the hole, and be there retained till evaporated. This (finding of sand) is very often the case with white oak. Did the insects carry it there? Did the birds carry it there? Did the wind drift it there? If the latter, then the rough outside bark would hold much of it in the crevices. But not a grain could I find there.[1] Then there are the leaves of the trees, which by a careful invesgation I found to be, when compressed, equal to the last growth of the mother tree, or in the life time of a tree the compressed leaf fall is equal to the wood volume of the tree above ground. The compressed annual leaf fall in our dense forest I found to be one thirtieth of an inch. The body of the trees will make the same volume as the compressed leaf fall of their life-time. (I don't claim this as mathematically exact, but it is approximate.) Thirty years will make one inch of compressed leaf fall. One thousand years will make thirty-three (or more) inches. The bodies of the trees making as much more, we have sixty-six inches of decomposed trees and leaves for one thousand years—not allowing that any part will be reconsumed by the succeeding trees. Then add the unknowable volume of dead buffalo, deer, bear, and other animals, together with the birds and insects, with the excrement of all three during their lifetime, and we have a great volume of recently created matter, some of which must remain on the surface in some form. What form more probable than the surface yellow clay? This too is consistent with the thicker clay on the higher lands where vegetation first existed.

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[1] Very recently I have found dark sand in several hollow black-walnuts, where the hollow was at the ground and the sand was mixed with the rotten wood inside the trees and three to seven feet above the outside opening; so that it was impossible for the rains to have washed it into the tree, and very, very improbable that it was carried in by the wind. Beside, I must remark again, that if carried in by the wind the crevices in the rough bark should also contain a great amount, but it takes the closest search to find a single grain.

But chemistry teaches that it is impossible that trees, roots, leaves, and the flesh and blood of animals, birds and insects should turn to clay or sand. Then the more wonderful the facts I submit herein. For the time being I shall treat the facts according to their appearances, for appearances point so strongly, that the investigator on the field, shovel in hand, requires a constant effort to doubt them. But I remember too that the appearance of the surface of the earth is flat.

But here is a large erratic glacial bowlder on top of very recent creation. Why was it not covered by this recent creation? Ah, I see; once on top by any accident at the end of the glacial epoch, the subsequent freezing and thawing would keep it there. The freeze takes place at the outer edges first, forms an air-tight box, and in expanding lifts the bowlder, thus forcing a vacuum under it, which is filled with water by suction, which water is next frozen, causing still another lift and expansion. This second lift raises the bowlder above the first outside frozen support, causing a crevice. The succeeding thaw, which takes place first at the outer edges, forms a thin slush which fills the crevices, acting thus as props or supporting or staying wedges. Sometimes a bowlder will be so covered with a drift of leaves or the fall of a tree that the freeze does not get enough under to lift it. Then it ceases to climb on top as the building goes on, and it will in time be found in the midst of the surface yellow clay as we have often seen them.

Then again we find stray glacial gravel interspersed among the gravelless clay. Query—How came it there? The crows may have carried it and dropped the pebbles, as they do to-day; or the squirrel and other similar habited animals in digging through the leaves after fallen nuts may have kept them scratched up to the surface for a long time, and then by chance they were overtaken by a leaf drift, and remained where we find them to-day, in the midst of the surface clay. Also, animals burrowing in the gravel would carry the gravel up from their holes and leave it on the surface.

Then the roots of the trees cut a great figure in this work. Think of the millions, yea, billions of roots and rootlets that have occupied the upper part of the gravel. I feel confident that there is not a cubic inch of ground in the forests as they exist here, that has not been occupied by a root or rootlet, from the surface to three feet down, in the last thousand years. What has become of them? In twenty years at most after cutting down a forest, no trace of the roots or rootlets can be found here. They do not leave their cast, or even a trace of brown mould.

About two years ago I was riding homeward over the gravel road south-east of here (Rockville, Indiana), noticing the exposures along the road gutters. In many exposures the line between the "upper yellow clay" (as it is called here) and the under glacial clay (mixed with gravel) was as distinct and marked as the crack in a floor. When near the hill top on the east side of Raccoon creek, the surface clay suddenly changed to yellow sand. Away went my theory in a minute, which I had been years building. There was a small locality where the surface was sand instead of clay. Trees had grown, shed their leaves, died and rotted there, and been succeeded by others as abundantly as where clay existed. Do trees turn to sand also? I queried. Scarcely probable. But what has become of the trees, their leaves and rootlets, that have been growing on and in this sand for thousands and thousands of years? A little brown surface mould about six inches thick is all I can see to represent them.

Last May, while locating a bridge site across said Raccoon creek, I noticed in the steep bank the ends of the roots and rootlets of stumps and dead trees, and in some of them all had decayed and been consumed except the bark, which was filled with a sandy loam the same as the surrounding earth. Been carried into the hollow bank by the floods, I thought. But I dug into the bank after them, and found them thus filled in the bank a distance of over three feet; and in following these into the bank I ran across still others filled in in like manner, and lying parallel to the lines of the bank, where the flood never had touched them. Some of the roots were simply rotten wood inside of the bark, which was still fairly sound, for the bark is the last part to rot. Some root bark was filled with a mixture of sand and rotten wood. One was filled with rotten wood and a seam of sand shaped like a thick-backed knife blade lying lengthwise of the root, the back resting on the bottom, and the edge reaching to the top side of the hollow root bark. Since that time I have examined many roots along hillside exposures by the roadsides, and have found that the bark of the roots at a certain stage of decay will be filled with the same kind of earth in which the root lies. This would suggest that the sand or clay is carried into the hollow bark by insects. But I have found such root bark packed full of sand or clay where I thought it impossible for any insects large enough to handle such matter to get in, unless on leaving they sealed the hole so perfectly as to baffle observation. Last week I found one root bark about four feet long, the butt end filled with rotten wood and sandy clay about equally intermixed. The middle part was packed tight with sandy clay, and the top or smaller end was filled with damp rotten wood. In this case there was no noticeable insect pathway to the middle. I have dug trenches around old stumps and dead trees two to three feet deep to see what the old roots would show. Many showed at a distance of eight feet from the stump no traces of the roots whatsoever. In some I have found the common ants, and with them dark balls or lobes of mud about the shape of wheat grains, and a quarter to a third the size of the wheat. The teeth could plainly detect the grit in them.

Suppose the trees do not reform into clay and sand, and that the insects carry the sand and clay into the root bark and into the rotten logs and stumps. They can carry none but the finest material. The gravel would be left behind, and this alone would in time work the finer material to the top.

The crawfish is an industrious agent in wet lands in bringing up the lower earth to the surface. I have been examining their holes for the past six months, and in that time I have failed to find them bringing up any coarse material, though boring through the yellow into the glacial clay. I have so far found no gravel larger than bird shot in the cones which they build up about the top of their holes. The crawfish is a queer citizen. I can't understand him. I fail to see where he puts all the dirt that must come out of his hole. Last year I poured about a bushel of dry sand into one of his holes where many others were dug near by without filling it; yet the mud balls he had stacked up about the hole would not have filled my hat crown.

The ants too are known to bring a considerable quantity of earth from beneath to the surface in building their hills. Only a few days ago I was surveying in a five-acre cow pasture at Rosedale, a village in the south part of this county, and there I noticed that wherever the excrement of the cow was dropped, a bug which lays its eggs in a ball of the excrement and buries it in the ground, had carried up great quantities of fine earth from the excavations below. At a very recent one there was fully a gallon of fine earth piled up on the ground. This was on the second or terrace bottom of Raccoon creek, and over a gravelly subsoil.

On the insect hypothesis, there would of course be a limit to the thickness of each surface formation. Insects will dig no deeper than will serve their necessities. I have no reason to suppose they would go deeper than three feet; but I have often seen the yellow clay ten to twelve feet thick on the high ridges. This would require a deep digging insect, or else an accumulation from some source above the surface. The crawfish would dig deep enough, but he leaves the field when it becomes high and dry. Besides this, if the fine material had been taken out of the top of the glacial, gravelly clay, it would have left a stratum of clean gravel as far down as the fine material had been thus extracted, which we do not find to be the case here.

I notice in the second or terrace bottoms along the Wabash river in this vicinity a coat of fine sandy loam on top of the original gravel and sand, which latter was left by the Wabash when it carried ten thousand times as much water as it now does. There has never been any slack water over these terrace bottoms since the Wabash which made them dropped into its present limits. I shall some time try to prove what I here merely assert, to-wit: That the ancient water supply of the Wabash was suddenly cut off, and there was one last great flood, which left its natural marks, and there has never been another large enough to efface or even modify these marks. Therefore the loess covering of these terrace bottoms must have some other than an aquatic origin.

In the flat table lands of the Wabash country, where the rainfalls have lain on the ground till removed by evaporation, the surface clay has an ashen color. On the high ridges, and at the crests of hills or ravines in the flat wet lands before mentioned, the surface clay is yellow, or buff colored. In the terrace river and creek bottoms the color is generally ashen, and the material a sandy loam, with occasional spots of pure yellow clay.

If this loess is decomposed vegetable and animal matter, why does it assume so many shades of color, and varied coarseness or fineness of shades of sand grain, being buff colored on the high land, ashen on the flat and the terrace bottoms, black in the Illinois prairies, and Indiana swamps? I do not pretend to answer, "Sufficient unto the day is the evil thereof." Nor do I know why the first fifteen outside growths of a white oak (and varying numbers for other trees) are white and will decay in a short time after the tree is killed, and all the inner growths are red and will endure the weather many years after the white growths are gone; but it is a *fact.* Fifteen years from to-day, all the present white growths will be red and far more durable, and new white growths will have formed outside of them.

My observations have been confined to my own locality, and my deductions may be very wrong. I submit them for whatever they may be worth.